6C7

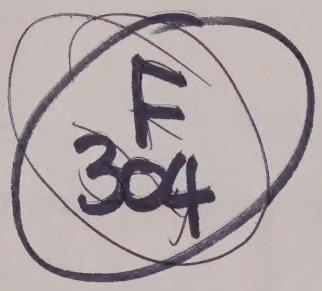
# INSTRUCTION MANUAL

FEC

## *Sensitive Research**

UNIVERSAL 88 POLYRANGER

MODEL U88



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2-642N

*Precision electrical and electronic instruments for measurement*

THE SINGER COMPANY • METRICS DIVISION

Ref.

**To the user of SINGER Instrumentation:**

SINGER instruments are fabricated and tested under conditions of rigid manufacturing and quality control according to the best practice of the current state of the art. In addition, our Service and Applications Sections are available to you at any time.

The registration of your instruments and any comments will be most appreciated. The information concerning fields of application will aid us in providing you with pertinent literature from time to time.

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Date..... CONDITION ON ARRIVAL.....

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**915 Pembroke Street**
**Bridgeport 8, Conn.**

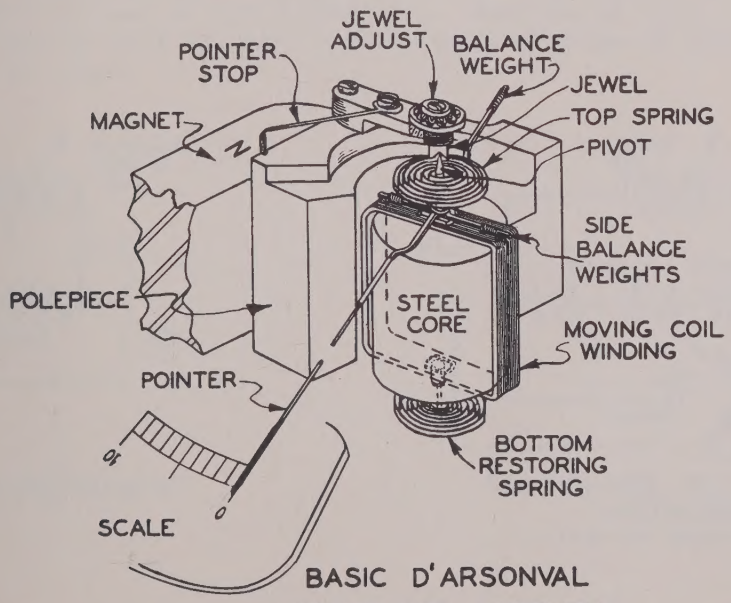
# ELECTRICAL MEASURING INSTRUMENTS

## D. C. CURRENT MEASUREMENTS

Almost all electrical measurements involve the detection or measurement of an electric current. An electric current can be measured by means of one or more of its physical effects;

1. Heating Effect
2. Chemical Effect
3. Magnetic Effect

Using the magnetic effect caused by a current flow, we can devise an accurate means of measurement. The oldest design of such a device is known as the D'Arsonval Moving Coil System. An elementary sketch of which is shown below.




BASIC D'ARSONVAL MOVING COIL ASSEMBLY

Its operation depends on the force exerted on a current carrying conductor shaped in a coil which is capable of rotation in the field of a permanent magnet.

When a D.C. current flows through this rotatable coil, it creates a field which interacts with the permanent magnet field and produces a torque.

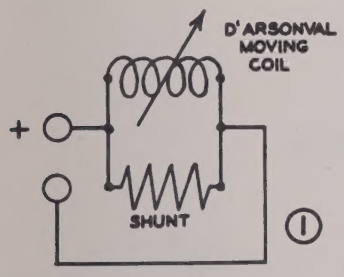
This torque is proportional to the magnet strength, the current in the moving coil, and the number and area of the moving coil turns. The torque produced rotates the mobing coil until its spiral springs are wound up sufficiently to produce an equal and opposite torque. When this point is reached the pointer deflection will be directly proportional to the current which produced it.

Essentially, a D'Arsonval moving coil, which in Sensitive Research Instrument is reactangular in shape, has a steel or diamond pivot at each end which turns in spring mounted jewel bearings.

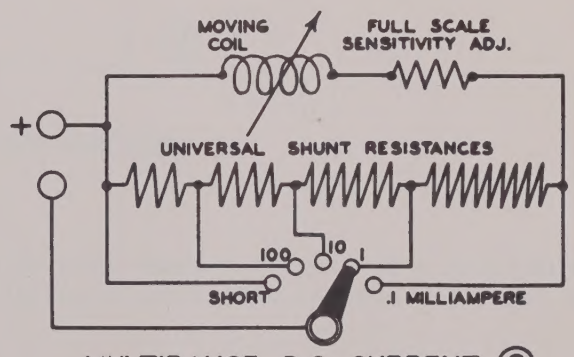
The D.C. current enters and leaves the moving coil usually through spirally constructed phosphor bronze springs which are coiled in opposite directions. These springs also provide the controlling force which opposes the deflecting force created by the current flow through the moving coil turns.

The accuracy of such an assembly to date is superior to any other known type of current deflected mechanism for electrical measuring instruments.

As such a moving coil system will not usually carry over 30 milliamperes without heating errors, we shunt any additional current past the moving coil. By means of calculated and accurately constructed shunts, either single or in a multiple system, we can measure D.C. currents of large magnitude even though the moving coil is only carrying and measuring 30 milliamperes or less. (See circuits below)




SHUNTED INSTRUMENT




MULTIRANGE D.C. CURRENT ② INSTRUMENT
.1-1-10-100 MILLIAMPERES

SENSITIVE RESEARCH has developed and improved during the past 31 years the basic D'Arsonval moving coil system so that today we use it even in our 1/20 of 1% LABORATORY STANDARD D.C. Instruments.

When properly constructed, a D'Arsonval moving coil system will accurately measure very minute D.C. currents as low as .01 of one microampere (.00000001 ampere) and indicate this small magnitude of current by a pointer on an indicating scale drawn in divisions-deflection. This extremely high sensitivity is unusual in portable indicating D.C. Instruments.

## D. C. VOLTAGE MEASUREMENTS

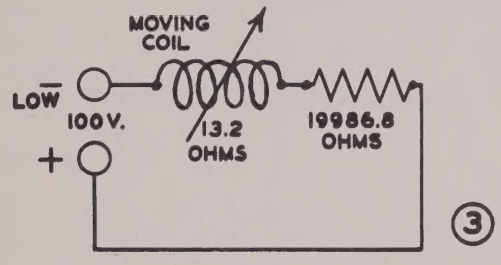
The D'Arsonval moving coil system movement is a current measuring device, but by following a principle of ohms law we can use this current measuring movement to measure D.C. voltage.

FOR EXAMPLE

Assume we wish to measure 100 volts direct current. Also assume that we have a D'Arsonval movement that deflects full scale for 5 milliamperes with a resistance of 13.2 ohms. By Ohms Law, 100 volts across a circuit of 20000 ohms will have a current flow of 5 milliamperes (.005 amperes) by:

$$\frac{100 \text{ Volts}}{.005} = 20000 \text{ Ohms}$$

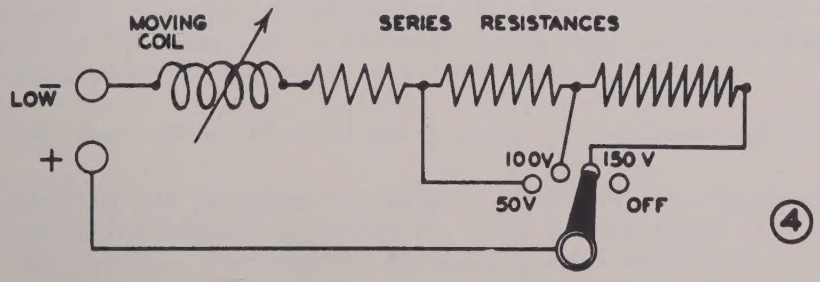
If we place our D'Arsonval moving coil (13.2 ohms) in series with a 19986.8 ohms resistor to equal 20000 ohms;




SIMPLE
SINGLE RANGE VOLTMETER
100 VOLTS

Then a potential of 100 D.C. volts will cause a current of 5 milliamperes (.005 ampere). Moving coil pointer deflection can then be calibrated and marked on the scale as 100 volts.

Using the ohms law formula and suitable calculated resistances, we can readily construct multirange D.C. Voltmeters.




MULTIRANGE D.C. VOLTMETER
50 - 100 - 150 VOLTS

## GENERAL INFORMATION

Upon receipt, your instrument should be carefully unpacked and examined for any visible external damage, i.e; split case, cracked glass, broken binding posts, etc. Place the instrument on a reasonably level bench. If the instrument has a wire shunting (across) the terminals, it should be removed. With the mechanical zero adjuster thumb knob, move the pointer both above and below the zero line of the scale. It should have sufficient travel to go a little beyond zero in each direction. Set the pointer exactly on zero while lightly tapping the instrument case with your fingers. The pointer will be correctly adjusted for zero when no reflection of the pointer's knife edge can be seen in the anti-parrallax mirror and the pointer is directly over and in line with the scale zero.

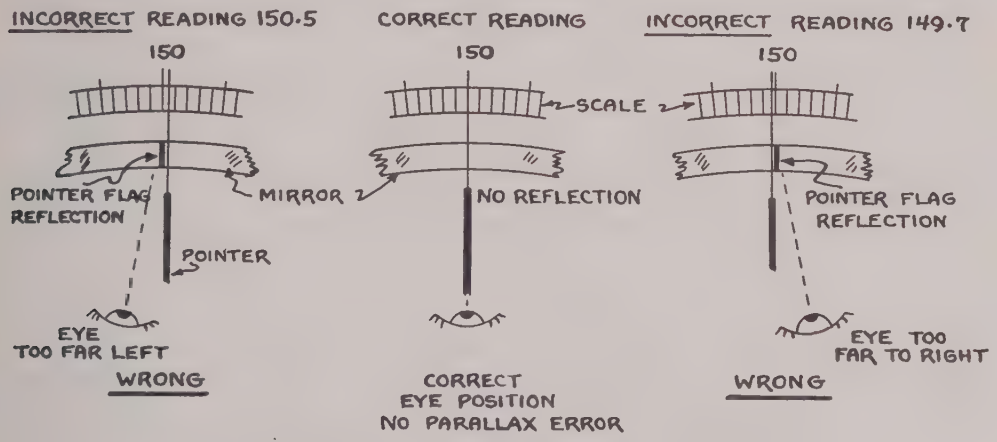



ILLUSTRATION OF THE ANTI-PARALLAX PRINCIPLE

The pointer indication should only be "read" when no reflection of its knife edge can be seen in the mirror below. This is only obtained when the eye is directly over the pointer. The drawings above illustrate the anti-parallax principle.

## BALANCE TESTS FOR DIRECT CURRENT INSTRUMENTS

The general testing procedure for balance on all portable and panel instruments is the same, the difference being only in the degree of angle that the instrument is tipped from a horizontal position.

1. See that the pointer is set exactly on its zero position.

2. Now tip the instrument slowly up from the side farthest from you to an angular position as shown on the table below, and tap gently. The pointer should NOT move more than the amount shown on the table below.

3. Next, lay the instrument flat again and then tip it on its side, first left, then right, and tap gently.

In both of these procedures, the instrument should be within its balance specifications. In general, these specifications are as follows:

DIRECT CURRENT INSTRUMENTS

| MODEL | ACCURACY | ANGLE FROM HORIZONTAL | BALANCE GUARANTEE |
|---|---|---|---|
| UPP PANEL | .5 of 1% | 90° | .5 of 1% |
| UP PANEL | 1% | 90° | .5 of 1% |
| J,JW,S, UNIVERSITY PORTABLE | .5 of 1% | 25° | .5 of 1% |
| C PORTABLE | .25 of 1% | 25° | .25 of 1% |
| B LAB. STANDARD | .1 of 1% | 10° | .1 |

FRICTION TESTS

The instrument may be tested for mechanical friction at this point by connecting it to a suitable source of power and deflecting it at least 25% of full scale, then reducing the deflecting current to zero. No instrument should be accepted for use if it has any appreciable friction.

CALIBRATION CHECK

No actual calibration check should be made until the instrument has become thoroughly temperature saturated at ambient room temperatures for at least four hours. Allow it to reach room temperature. SENSITIVE RESEARCH calibrates all instruments at exactly 25° C.

Make sure you are on the right range for your power supply. If in doubt set the range switch, if any, on the instrument on its highest range. This will prevent overloading of the instrument when starting any electrical tests. If only a slight pointer deflection results when power is applied, then successively switch the instrument range selector DOWN until a suitable reading is obtained. Bring the pointer up to full scale and open the instrument circuit. A special precaution should be taken by the user of thermocouple instruments: AVOID opening the primary circuit of a transformer whose secondary circuit is being measured by thermocouple instruments. The reason for this is that the transformer as an energy storing device may, under certain conditions, DISCHARGE its energy into the secondary circuit, thereby overloading the thermocouple instrument. (Overloads of 1000% are quite possible in transformer circuits.)

This danger can be eliminated by either disconnecting the instrument from the secondary circuit which can be turned to "zero" so that the excitation of any transformer primary may be reduced to "zero" before switching off.

The pointer should return to its original zero without tapping. If it returns to zero only when tapped, it indicates friction in the movement and possible damage to the pivots and jewels, possible through some severe shock in transit. For portable instruments with an overall accuracy of .5 of 1% or higher, and all high torque panel types, the pointer should return to exactly zero. Ultra high sensitivity instruments in the 1% class, and thermocouple instruments in the .75 of 1% class should have a maximum deviation from zero to no more than .1 of 1% of the physical length of the scale.

The pointer should then be deflected using controlled power slowly up and down the instrument scale. The pointer action should be smooth and there should be no sticking or hesitation at any point on the scale. Do not, however, mistake a rough spot in the controls of your power supply for a "stick" in the movement. Often, a badly regulated power supply or a loose circuit connection may make the instrument appear to have an internal variable. All instrument links and leads should be carefully attached and tightened.

The new instrument should be checked against an accurate standard on the cardinal points of the scale. Just one word of CAUTION. Be careful that you do not place your new instrument and your standard too close together, especially with D.C. instruments. They may react magnetically on each other if your standard instrument is not magnetically shielded, it might indicate incorrect readings. Keep them at least six inches apart. Also, if the instrument was specially ordered for use on a steel panel (such information is printed on all our scales) then test it on a steel panel of the specified thickness.

Of all the things, that may be wrong when you get a new instrument, incorrect calibration is the LEAST likely; and if present at all, it will usually be caused by bad balance which you will already have detected by the test just covered. 99.99% of the instruments you receive, if they are satisfactory for balance, friction, stickiness etc., will also be well within their guaranteed accuracy.

NOTE:

Disassembly of the movement should not be attempted unless a skilled instrument man with calibration and scale drawing equipment are available.

## CARE AND MAINTENANCE

All SENSITIVE RESEARCH instruments are individually assembled by skilled instrument makers and are INDIVIDUALLY calibrated. We do not calibrate instruments "en masse". Extreme care has been used in selecting pivots and shock mounted jewel bearings. In some instruments DIAMOND PIVOTS are used.

The instrument should be used and treated as a precision standard. A reasonable amount of care will bring its reward in a lifetime of accurate service.

Good practice dictates that periodic checks be made for pivot friction, coil, balance, scale calibration, and the mechanical integrity of any instrument.

If the instrument glass is cleaned by any method, the task should be completed by heavily breathing upon the glass so as to dissipate any electrostatic charges that may have been generated by friction. Occasionally the binding posts metal contact surfaces should be cleaned and brightened by the careful use of a fine sandpaper. A yearly coat of wax on any wooden instrument case is suggested.

Instrument panels are cleaned by using carbon tetrochloride to dissolve any greasy surface accumulations. A brisk rubbing with a soft flannel cloth will restore our moulded panels to their original lustre. Should the engraving "white" become discolored it can be removed with a sharp point and refilled with a white wax crayon material obtained from us.

OPERATICNAL PROCEDURE

1. Place the instrument on a level surface so that the scale is horizontal. Deviations of more than 5° from the horizontal may affect accuracy adversely.

2. For good instrument practice, the instrument should be kept away from any source of very strong magnetic fields. Maximum tolerable field is 5 oersted.

3. Set the pointer on zero by rotating the zero shifter, using thumb or zero screw. The pointer is correctly set on zero when the reflection of the pointer in the antiparallax mirror coincides with the pointer itself and with the zero line. (See general information sheets.) Page 4

4. For safety it is best to turn off the current or voltage to be measured before making connections to any instrument. Observing proper polarity, connect the instrument terminals in series with the circuit if current is to be measured.

   If voltage is to be measured then the voltmeter is to be in parallel to the portion of the circuit desired. It is important to remember that when an ammeter (current measuring instrument) is inserted in series with a circuit, the circuit is changed by the introduction of the ammeter resistance. Ammeters are therefore designed to be of low resistance so that they will only be a small fraction of the total resistance of a circuit.

   Remember also that when a voltmeter is connected across (in parallel) with a portion of a circuit it changes the potential difference by its own effect on the circuit and since it also is connected in parallel with a part of the circuit it reduces the effective resistance of that portion which increases in some degree the total current flowing in the complete circuit.

   Therefore voltmeters are designed to have the highest resistance possible so as not to change materially any circuit to which they may be applied.

5. It is considered good instrument practice in multirange instruments to have the range switch on the highest possible range and then the user can progressively switch down to the range that produces an acceptable reading. A good acceptable reading would be one in which the pointer is indicating in the upper fifth of the scale. (Nearly maximum deflection.) Apply power and observe pointer deflection. When the instrument pointer has come to rest, the current is indicated by the position of the pointer on the scale.

6. After the desired measurements have completed, turn off the current supply and disconnect the instrument terminals from the source of current. If the instrument leads are left connected and circuit changes made damage could result to the instrument being on a range setting lower than the newly applied power value.

SENSITIVE RESEARCH INSTRUMENTS have a data card attached to it or mounted in its case. This data card detailing the accuracy and electrical characteristics together with the instrument panel engraving will readily enable the user to operate our instruments to their full accuracy and their personal satisfaction.

## THE UNIVERSAL "88"

Due to the great diversity of currents and voltages required in the laboratory, it has been almost impossible in the past for one instrument to efficiently make all required measurements accurately.

The basic circuit principles described on the preceeding pages have been applied by SENSITIVE RESEARCH to successfully produce an 88 range A.C. and D.C. instruments that is simple in operation:

The instrument ranges overlap each other so that all readings can be taken on the upper half of the scale. This is considered good instrument practice.

The panel engraving is colored in red and white which makes the selection of ranges very easy. The "UNIVERSAL 88" has:

24 Ranges in D.C. CURRENT
from 200 microamperes full scale to 1.5 amperes.

28 Ranges in D.C. VOLTAGE
from 20 millivolts full scale to 750 volts.

16 Ranges in A.C. CURRENT
D.C. or A.C. up to 15000 cycles up to 1 ampere
5000 cycles over 1 ampere

20 Ranges in A.C. VOLTS
(D.C. or A.C. up to 5000 cycles)
from .5 volt full scale up to 750 volts.

TOTAL 88 RANGES

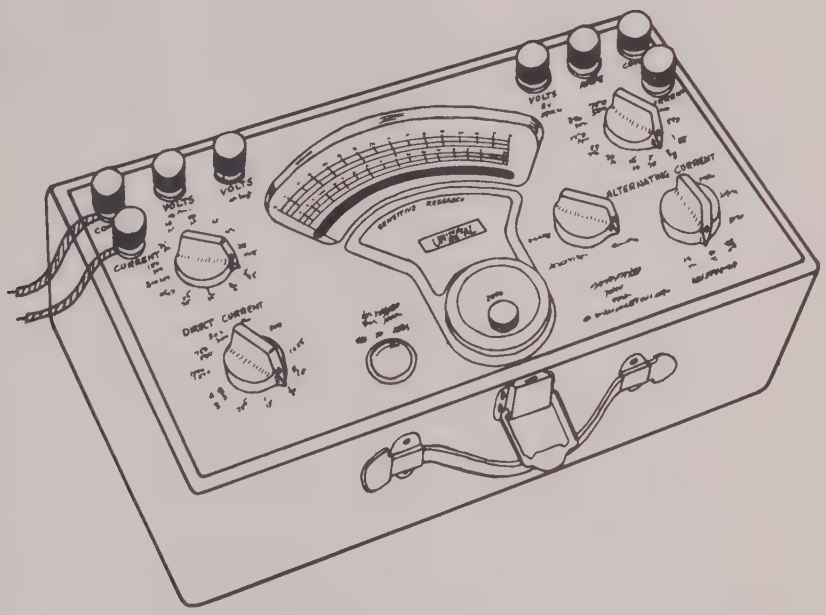
### OPERATION OF THE "UNIVERSAL 88"

The instrument consists of two separate electrical sections, one for D.C. and the other for A.C. measurements. A single D'Arsonval movement is used and it is switched from D.C. to A.C. as required. The A.C. side uses a vacuum thermocouple to produce a small D.C. voltage which is created by the flow of current either A.C. or D.C. through its heater circuit. This D.C. millivoltage is accurately measured by the instruments D'Arsonval movement.

Since the two circuits are not connected to the moving coil at the same time, both A.C. and D.C. can be applied SIMULTANEOUSLY. Then by changing the circuit selector switch on the panel, the A.C. and the D.C. could be compared at the same time even though it is not considered good instrument practice.

The D.C. section is on the left side of the instrument panel, the A.C. on the right. When you receive the instrument you will notice that the instrument pointer is very sluggish. This is due to the "CIRCUIT SELECTOR SWITCH" being in its "TRANSIT" position. If switched to any other position, the pointer will act freely on D.C. and somewhat more damped on A.C. due to the thermocouple circuit.

**CONNECTIONS FOR D.C. CURRENT 24 FULL SCALE RANGES COMPLETELY SWITCH CONTROLLED FROM .2 MILLIAMPERE TO 1500 MILLIAMPERES**

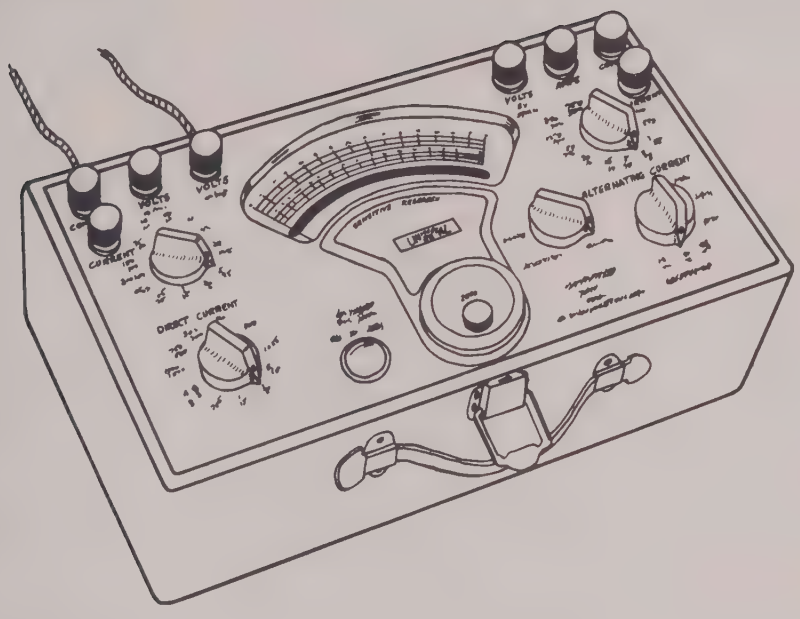



D.C. CURRENT MEASUREMENTS
(.0002 Ampere to 1.5 Amperes)

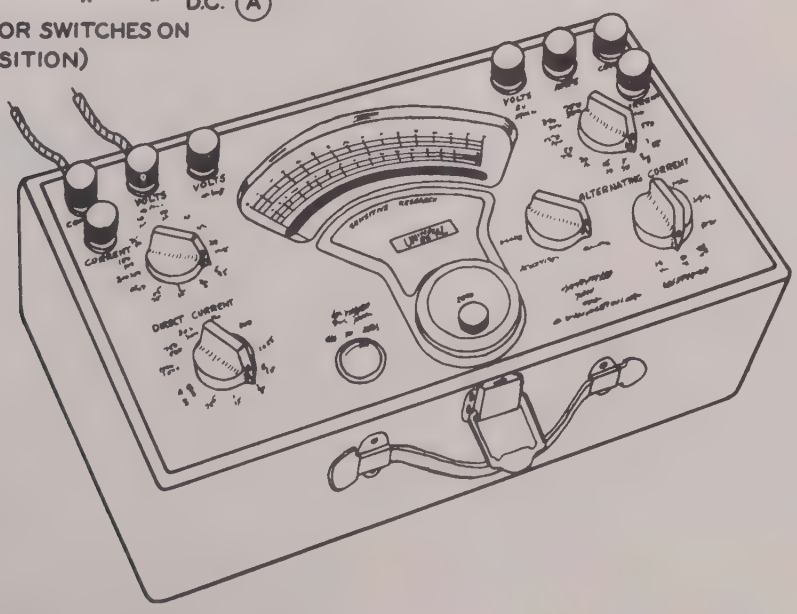
From .2 milliampere up to 1500 milliamperes (full scale values), connect a lead each to the "-COMMON" Binding Post and the Binding Post below it. These posts are marked "D.C. CURRENT." The lower selector switch marked "D.C. CURRENT" selects the ranges. You will notice that each switch position has two markings. For instance, the lowest position is marked .2 in white, and .3 in red. If the circuit selector switch is on its white D.C. position (also called "B"), the range is .2 milliampere or 200 microamperes. If the circuit selector switch is on its red D.C. position (also called "A"), the range is .3 milliampere or 300 microamperes. This means that you can select the white or red range on EACH engraved selector switch position by simply changing the "CIRCUIT SELECTOR SWITCH" from its white to red position.

EXAMPLE: Take the highest selector switch range marked 1000 milliamperes in white and 1500 milliamperes in red. Either the 1000 or 1500 milliampere range can be used by moving the "CIRCUIT SELECTOR SWITCH" to the color range desired. (White for 1000 milliamperes and red for 1500 milliamperes.)

CONNECTIONS FOR
D.C. VOLTAGE
22 FULL SCALE RANGES
COMPLETELY
SWITCH CONTROLLED
FROM .02 VOLT
TO 300 VOLTS




CONNECTIONS FOR
FULL SCALE D.C. VOLTS
500 VOLTS WITH CIRCUIT SWITCH ON D.C. (B)
&
750 VOLTS " " " " D.C. (A)
(RANGE SELECTOR SWITCHES ON
ANY POSITION)



## D.C. VOLTAGE MEASUREMENTS
(.02 volt to 300 volts by volt range selector switch)

The same general procedure on current is followed. Use the "COMMON" Post and the binding post marked "VOLTS BY SWITCH." Like the current selector switches, there are two volt ranges for each range selector switch position marked in white and red, which are selected by the "CIRCUIT SELECTOR SWITCH." For voltage above 300 volts use the separate binding post marked "500 VOLTS" in white and "750 VOLTS" in red using the "CIRCUIT SELECTOR SWITCH" as described.

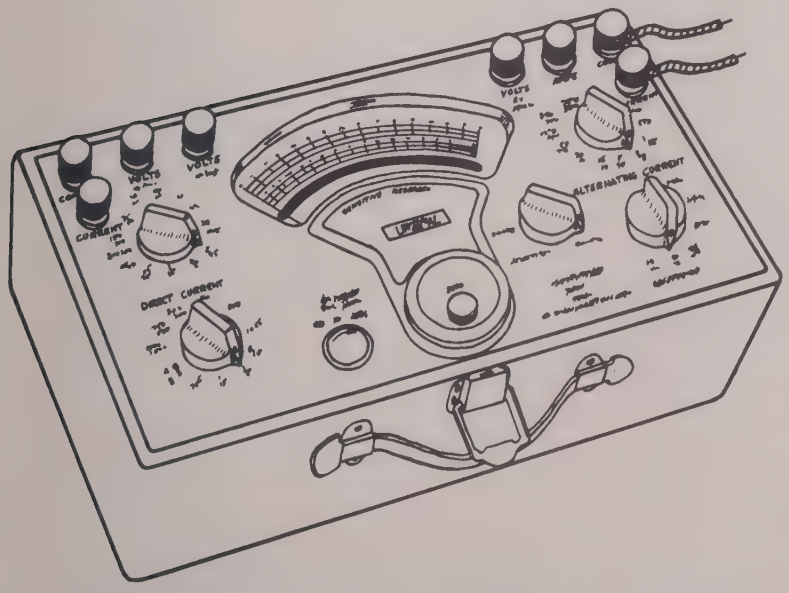
See connections preceeding page

## A.C. CURRENT MEASUREMENTS
(.01 Ampere to 1.5 Amperes)

For A.C. measurements the "CIRCUIT SELECTOR SWITCH" MUST PASS THROUGH a safety position BEFORE it gets to its white and red circuit selector position. This prevents any accidental burnout in changing from D.C. to A.C. Use the "COMMON" and "A.C. CURRENT" binding posts.

Similar to the D.C. range selector switches, the A.C. range selector switches have white and red engraving on each position. These are selected by the "CIRCUIT SELECTOR SWITCH" in its white or red positions.

For current above 1.5 amperes A.C., use the "COMMON-" and the binding post to its left.



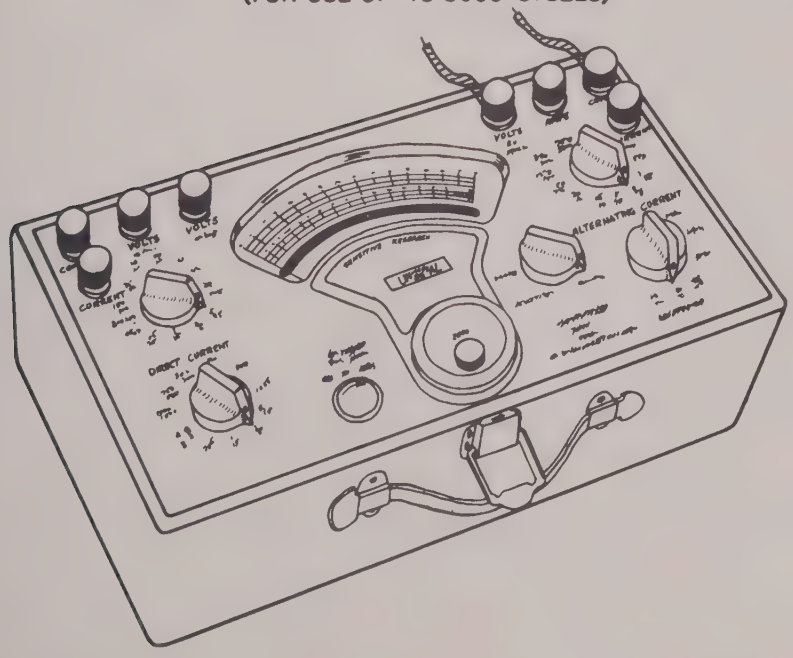

CONNECTIONS FOR
A.C. CURRENT
14 FULL SCALE RANGES
COMPLETELY
SWITCH CONTROLLED
FROM 10 MILLIAMPERES
TO 1500 MILLIAMPERES
(FOR USE UP TO 15000 CYCLES)

## A.C. VOLTAGE MEASUREMENTS
## (.5 to 750 volts)

Use the "COMMON" and "VOLTS BY SWITCH" Binding Post and follow the same procedure as above described.

The user will notice a red line drawn near "Zero" on the instrument scale, marked "SAFETY." IF, when A.C. current or voltage is applied, the instrument reads ABOVE this red line, when either the "CIRCUIT SELECTOR SWITCH" is on "SAFETY" or if the PUSH BUTTON SAFETY is NOT depressed, it means that the instrument is overloaded. Reduce either the current or voltage to a point below the red line before changing the A.C. Switch OR before depressing the A.C. Safety Key. This A.C. Safety switching does NOT affect any external circuit.

CONNECTIONS FOR
A.C. VOLTAGE
20 FULL SCALE RANGES
COMPLETELY
SWITCH CONTROLLED
FROM .5 VOLT
TO 750 VOLTS
(FOR USE UP TO 5000 CYCLES)




It takes longer to read how to obtain any of the 88 available ranges than to operate the very simple switching.

As time passes, the continued daily use of this highly flexible and accurate UNIVERSAL 88 will be more and more appreciated.

## INSTRUMENT DETAILS

### AUTOMATIC TEMPERATURE COMPENSATION

Ever since thermocouple instruments have been made (1890), they have had a very poor temperature coefficient. In most cases it was .2 of 1% per degree centigrade. This meant that if the instrument was used at temperatures that varied over ± 4°C from the usual standardizing temperature of 25°C, it would read out of its guaranteed accuracy and a temperature coefficient factor (1+.002 (T-25°C) x reading) had to be applied.

Our new "UNIVERSAL 88," we believe, is the FIRST electrical instrument to have automatic temperature compensation on BOTH D.C. and A.C.

For the usual range of room temperature 20°C to 30°C no temperature coefficient need ever be applied to our new "UNIVERSAL 88" instrument. This asset alone makes this instrument UNUSUAL AND DIFFERENT.

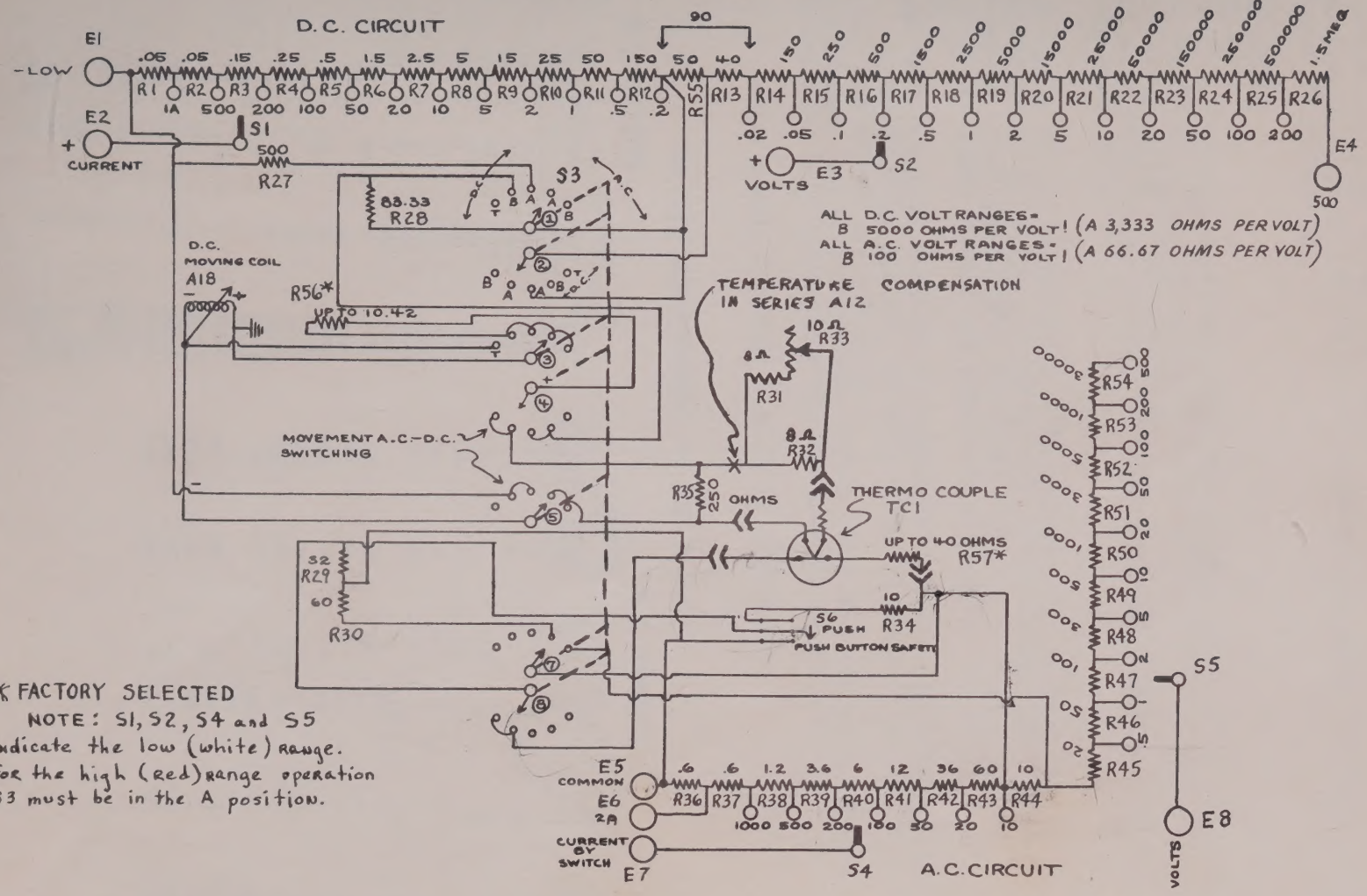
### THERMOCOUPLE PROTECTION

To date it has not been found practical to protect a VACUUM THERMO-COUPLE by any method of fusing, due to the high resistance that low current capacity fuses insert in the instrument circuit. Therefore we suggest the use of a protective device developed by ourselves which will protect any THERMO-COUPLE in our instrument up to a 1000% overload. Thermo-Couples without protection will just withstand 100% overload. We have been installing this protection for the past 30 years and have found it most practicable.

Briefly explained, it consists of a finger-operated pushbutton mounted on the panel surface, correctly adjusted shunts and a red safety line drawn on the instrument scale. When the safety is on, it shunts 4/5 of any applied current around the heater of the Thermo-Couple. NORMAL heater current will then only give a scale deflection of 1/5 reading. At this point on the instrument scale, a red line is drawn marked "Safety," Therefore, if when the instrument is put on test, it reads ABOVE the red line, it indicates that the instrument if being OVERLOADED. Current should therefore be reduced until pointer reads BELOW red line. Button is then depressed and the instrument reads the actual current.

The Safety Shunt is so compensated that its operation DOES NOT change the meter resistance or AFFECT any external circuit.

# THE NEW UNIVERSAL "88"




* FACTORY SELECTED

NOTE: S1, S2, S4 and S5 indicate the low (white) range. For the high (red) range operation S3 must be in the A position.

## THERMOCOUPLE REPLACEMENT

To replace the thermocouple element, proceed as follows:

a. Remove thermocouple access cover, located on the handle side of the case.
b. Remove defective thermocouple and insert one of known quality into the socket. Check for proper alignment of pin and socket.
c. Before replacing thermocouple access cover, a calibration check and sensitivity adjustment must be performed.

SENSITIVITY ADJUSTMENT.

Equipment Required:

a. A stable source of current or voltage which will produce a full scale meter deflection on the Model U-88. The source must be capable of maintaining an exact output for a period of at least 2 minutes.
b. A voltmeter or ammeter with an accuracy of .25%, which will cover one or more ranges of the Model U-88.

Procedure:

a. Connect the stable source to the Model U-88, ensuring correct polarity.
b. Connect the voltmeter or ammeter, in parallel or series (depending whether voltage or current is being measured) to the Model U-88.
c. Apply power to the stable source and adjust for full scale deflection on the Model U-88.
d. Check to see that the Model U-88 and the voltmeter or ammeter indications are identical. If the readings are not the same, turn the sensitivity adjustment until the two indications are identical.
e. After the adjustment has been performed, remove power from the stable source, disconnect the Model U-88 and replace the thermocouple access cover.

RANGE VALUES IN LOWEST READING AND RESISTANCE

### 88 FULL SCALE RANGES IN A.C. & D.C.

#### D.C. RANGES

**CURRENT**

| Full Scale Milliamps | Lowest Reading | Res. in Ohms |
|---|---|---|
| .2 | .002 | 10 |
| .3 | .004 | 60 |
| .5 | .005 | 61.5 |
| .75 | .01 | 70 |
| 1 | .01 | 40 |
| 1.5 | .02 | 42.3 |
| 2 | .02 | 23.6 |
| 3 | .04 | 23.1 |
| 5 | .05 | 9.6 |
| 7.5 | .1 | 9.7 |
| 10 | .1 | 4.9 |
| 15 | .2 | 4.9 |
| 20 | .2 | 2.5 |
| 30 | .4 | 2.5 |
| 50 | .5 | 1.0 |
| 75 | 1 | 1.0 |
| 100 | 1 | 0.5 |
| 150 | 2 | 0.5 |
| 200 | 2 | 0.25 |
| 300 | 4 | 0.25 |
| 500 | 5 | 0.1 |
| 750 | 10 | 0.1 |
| 1000 | 10 | 0.05 |
| 1500 | 20 | 0.05 |

**VOLTAGE**

| Full Scale Volts | Lowest Reading | Res. in Ohms |
|---|---|---|
| .02 | .0002 | 100 |
| .03 | .0004 | 100 |
| .05 | .0005 | 250 |
| .075 | .001 | 250 |
| .1 | .001 | 500 |
| .15 | .002 | 500 |
| .2 | .002 | 1000 |
| .3 | .004 | 1000 |
| .5 | .005 | 2500 |
| .75 | .01 | 2500 |
| 1 | .01 | 5000 |
| 1.5 | .02 | 5000 |
| 2 | .02 | 10000 |
| 3 | .04 | 10000 |
| 5 | .05 | 50000 |
| 7.5 | .1 | 25000 |
| 10 | .1 | 25000 |
| 15 | .2 | 50000 |
| 20 | .2 | 100000 |
| 30 | .2 | 100000 |
| 50 | .5 | 250000 |
| 75 | 1 | 250000 |
| 100 | 1 | 500000 |
| 150 | 2 | 500000 |
| 200 | 2 | 1 Meg. |
| 300 | 4 | 1 Meg. |
| 500 | 5 | 2.5 Meg. |
| 750 | 10 | 2.5 Meg. |

#### A.C. RANGES

**CURRENT**

| Full Scale Milliamps | Lowest Reading | Res. in Ohms |
|---|---|---|
| 10 | 2 | 30 |
| 15 | 3 | 20 |
| 20 | 4 | 37.4 |
| 30 | 6 | 34.9 |
| 50 | 10 | 20.1 |
| 75 | 15 | 19.7 |
| 100 | 20 | 10.8 |
| 150 | 30 | 10.6 |
| 200 | 40 | 5.5 |
| 300 | 60 | 5.4 |
| 500 | 100 | 2.4 |
| 750 | 150 | 2.3 |
| 1000 | 200 | 1.2 |
| 1500 | 300 | 1.1 |
| 2000 | 400 | .6 |
| 3000 | 600 | .6 |

**VOLTAGE**

| Full Scale Volts | Lowest Reading | Res. in Ohms |
|---|---|---|
| .5 | .1 | 50 |
| .75 | .15 | 50 |
| 1 | .2 | 100 |
| 1.5 | .3 | 100 |
| 2 | .4 | 200 |
| 3 | .6 | 200 |
| 5 | 1 | 500 |
| 7.5 | 1.5 | 500 |
| 10 | 2 | 1000 |
| 15 | 3 | 1000 |
| 20 | 4 | 2000 |
| 30 | 6 | 2000 |
| 50 | 10 | 5000 |
| 75 | 15 | 5000 |
| 100 | 20 | 10000 |
| 150 | 30 | 10000 |
| 200 | 40 | 20000 |
| 300 | 60 | 20000 |
| 500 | 100 | 50000 |
| 750 | 150 | 50000 |